# Snakes for lunch: bird predation on reptiles in a tropical floodplain

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## ABSTRACT

Based on collaboration between a wildlife photographer and a scientist, this paper provides novel information and images of predation by birds (Black-necked Storks, White-bellied Sea-Eagles, Whistling Kites) on reptiles (Macleay's Water Snakes, Keelback Snakes, Long-necked Turtles). The observations and photographs come from the wall of Fogg Dam, 60 km east of Darwin, the site of a long-term ecological research program on reptiles and amphibians. Professional ecologists rarely witness predation on their study animals, and this has been true at Fogg Dam despite >20 years' continuous research on reptiles at the site. The photographs provide the first specific records of predation upon reptiles by birds in this floodplain ecosystem.

**Key words:** behavioural observations, citizen science, mortality, predator-prey

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## Introduction

Recent decades have seen an explosion of research on the ecology of tropical ecosystems in Australia, but many basic aspects of animal ecology remain poorly understood. One of the major gaps involves predation. By definition, any individual of a prey species experiences only a single successful predation event during its life (i.e. at the end of its life). Thus, even when researchers conduct detailed studies on the ecology of that prey taxon, they may obtain little information either on the identity of their subject's predators, or on the details of predation events.

This is exactly the situation for an intensive study of reptile ecology at Fogg Dam, on the Adelaide River floodplain 60 km east of the city of Darwin. Beginning in the mid-1980s, the reptiles and amphibians at this site have been the subjects of detailed investigations of topics such as population ecology, life-history traits, climatically-driven shifts in demography and abundance and mating systems (e.g., Shine and Brown 2008; Brown *et al*. 2011). With the arrival of invasive Cane Toads (*Rhinella marina*) in 2005, the site has also been the focus of detailed studies on ecological interactions between the toads and native species (see Shine 2010 for a review). We have looked at scavenging of road-killed reptiles and frogs (Beckmann and Shine 2011), but we have virtually no detailed evidence on the consumption of live reptiles and amphibians by predators at this site. Our only documentation involves occasional consumption of radio-tracked snakes by predators (especially Yellow-Spotted Monitors, *Varanus panoptes*: Brown *et al*. 2011), and the discovery of shells of Long-necked Turtles (*Chelodina rugosa* in most published accounts, but recently transferred to *C. oblonga*: ICZN 2013) that have clearly been crushed by Saltwater Crocodiles (*Crocodylus porosus*: R. Shine, pers obs., 2000). We have assumed that birds are significant predators of reptiles, but have lacked any data on the topic. The senior author of this paper (DS) is a wildlife enthusiast who photographs birds and other wildlife on the wall of Fogg Dam. The dam wall separates the waterbody from the floodplain below, and is the site of most of the reptile-survey work conducted over the previous 15 years (e.g., Brown *et al*. 2011). Thus, photographs taken of predation by birds on native reptiles (during daylight hours) can clarify the biology of the prey species that have been studied extensively (during the night) over many years, in exactly the same area. In this paper, we describe and illustrate the major types of predatory interactions that DS has recorded at this site.

## Methods

DS photographed wildlife on the wall of Fogg Dam (12.621794 S, 131.305016 E) from the back of a vehicle (ute), using a Canon 5D Mark II or III, with a Canon 100-400 lens plus extender to give 800 mm focal length. The camera was supported by a Gitzo tripod with a gimbal head. Most photography was conducted in early morning or late afternoon. Photographs were taken year-round, but most records of predation were obtained in the period from May to August. We have chosen photographs to illustrate specific behaviours, but our comments on the frequency and timing of predation events are based on many other (often, unfilmed) observations as well.

## Results

### Predation on snakes

Two adult (male-female) pairs of Black-necked Storks

(*Ephippiorhynchus asiaticus*; commonly but erroneously known as Jabirus) forage along the floodplain below the dam wall, each with its own area (with occasional territorial disputes at the boundary). In this species, the sexes are easily distinguished by eye colour (dark brown in males, yellow in females: Marchant and Higgins 1990). They can be found foraging on snakes and fishes below the dam wall from late February to late June each year, when water levels are falling after the end of the wet-season rains. These birds take One-Gilled Eels (*Ophisternon gutturale*) as well as snakes. Eels, mostly Long-finned Eels (*Anguilla reinhardtii*) featured strongly in the prey of Black-necked Storks during a study in northern New South Wales (Clancy 2011). The storks move slowly through shallow water, apparently using visual cues to locate prey, then stabbing the bill into the water. This equates to the foraging technique described as 'walking in water with visual search' identified (along with ten other foraging techniques) in a study of Black-necked Storks in northern New South Wales (Clancy 2011). Both snakes and eels attempt to resist capture by hanging on to aquatic vegetation, and then by wrapping around the bird's bill. However, neither tactic is effective once a prey item has been seized by one of these powerful birds. The prey item is repeatedly smashed against the ground, then swallowed headfirst; ingestion can take up to 15 minutes. Our photographic records suggest that most of the snakes taken by Black-necked Storks are Macleay's Water Snakes (*Enhydris polylepis*, including large adult specimens; Fig. 1a,b). Keelback Snakes (*Tropidonophis mairii*) also are taken (Fig. 2).

### Predation on turtles

During the dry season (May-December), Long-necked Turtles frequently cross the dam wall as they move from the drying floodplain to the dam itself. Many turtles are taken for food by indigenous people, both by day and by night (D. Sergo and R. Shine, pers. obs., 2005). As they cross the dam wall, turtles are also taken by two species of raptors. A pair of White-bellied Sea-Eagles (*Haliaeetus leucogaster*) frequently feed in this area. These large birds are formidable predators, and are known to consume turtles and lizards in southern Australia (Debus 2008; Olsen *et al.* 2013) as well as in the Northern Territory (Corbett and Hertog 2011). At Fogg Dam, the male eagle is capable of swooping down, seizing a turtle by its neck and carrying it away without having to land (Fig. 3a). The smaller female typically lands beside the turtle and seizes it before carrying it back to a favoured tree (or its nest) to consume the turtle (Fig. 3b). Contrary to popular belief, we have not seen eagles drop turtles in order to crack their shells. Instead, the eagles use their beaks to tear out the turtle's head and neck, and then its limbs, and then any remaining edible tissue.

The other turtle predator is the Whistling Kite (*Haliastur sphenurus*). In other parts of Australia, this species has been recorded to include snakes and lizards in the diet, but not turtles (Fuentes *et al.* 2005). Lacking the power and massive talons of eagles, kites are unable to seize turtles in flight, although they sometimes try to do so (Fig. 4a,b). Usually, they land beside the turtle and begin to tear off chunks of flesh from the legs or head (Fig. 4c). Frequently, their meal is terminated by the arrival of a White-bellied Sea-Eagle that then takes possession of the (often, still-living) turtle. The eagles and kites engage in spectacular aerial combat, presumably reflecting intense competition for favoured prey items (Fig. 5).

## Discussion

Although our data do not quantify rates of predation, they provide unequivocal evidence of birds consuming reptiles on the wall of Fogg Dam. Our records support and extend published information on diets of these bird species. For example, Black-necked Storks have been recorded to eat snakes, including Filesnakes (Marchant and Higgins 2006) and hatchling Flatback Sea Turtles (*Natator depressus*; Whiting and Guinea 1999), but do not appear to have been recorded as predators on the species that we saw being taken at Fogg Dam. Studies from southern Australia on the two wide-ranging raptor species have recorded chelid turtles (presumably *Chelodina longicollis*: Marchant and Higgins 1993). More generally, all three of these avian predators have broad diets, and their consumption of reptiles is likely to be limited primarily by availability and ease of capture rather than specific dietary preferences. For example, in other parts of their Australian range, both White-bellied Sea-Eagles and Whistling Kites have been recorded as consuming snakes (Marchant and Higgins 1993; Corbett and Hertog 2011), but did not do so in the course of our study. Only a single case of predation by a Black-necked Stork on a turtle has been recorded at Fogg Dam (C. Beckmann, pers. comm., 2001), but, predation by this species on the Eastern Long-necked Turtle (*Chelodina longicollis*) in northern New South Wales has been documented (Clancy 2011).

The predation events we have documented are highly non-random, at several levels:

1. *Predator species involved.* – The Fogg Dam wall is home to a vast array of bird species, but we have only seen attacks on reptiles by three taxa. Even restricting attention to bird species that take animal prey, most are too small to take on an adult snake or turtle, or rely upon more specialized diets. Nonetheless, relatively small Whistling Kites are capable of capturing and consuming even large turtles. The shell of these (primarily aquatic) turtles does not completely cover the animal's head, neck, limbs or tail; and thus, the shell offers ineffective protection if the animal is caught on an open roadway by a bird with a bill sharp and large enough to tear flesh from unprotected parts of the turtle's body.

   Notably, Black-necked Storks took many snakes but few turtles; whereas the two raptor species (eagles and kites) took turtles but not snakes (even though the same predator species have been reported to take both prey types at other sites: Corbett and Hertog 2011). At Fogg Dam, the dietary difference between species is tied to predator morphology and foraging modes. The storks patrol shallow-water areas, and their long bills enable them to capture eels and snakes that are hidden well underwater. At Fogg Dam, snakes

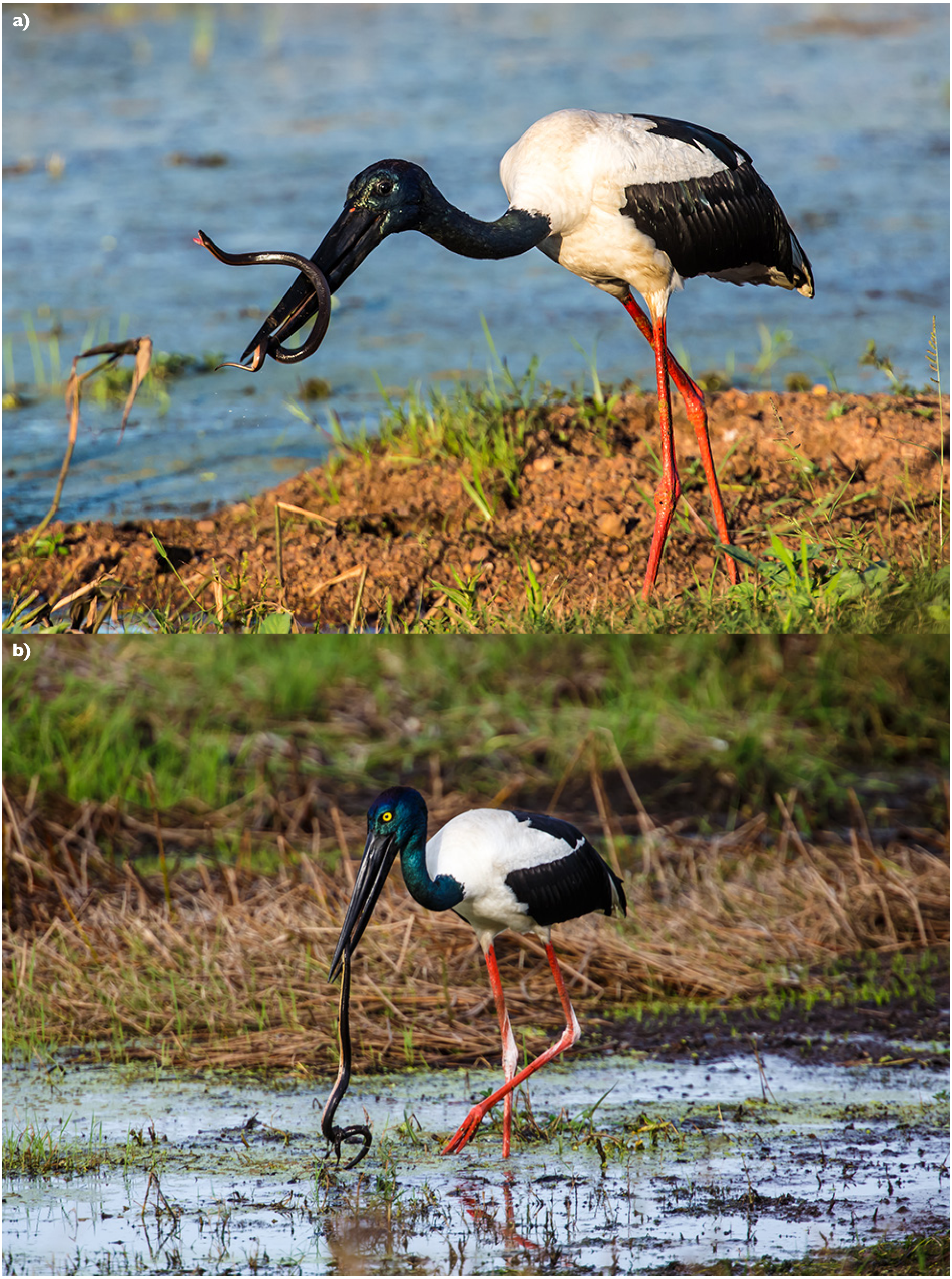

**Figure 1.** Male (a) and female (b) Black-necked Storks with Macleay's Water Snakes *Enhydris polylepis*. (a) Taken 21 May 2014, (b) taken 19 May 2014.

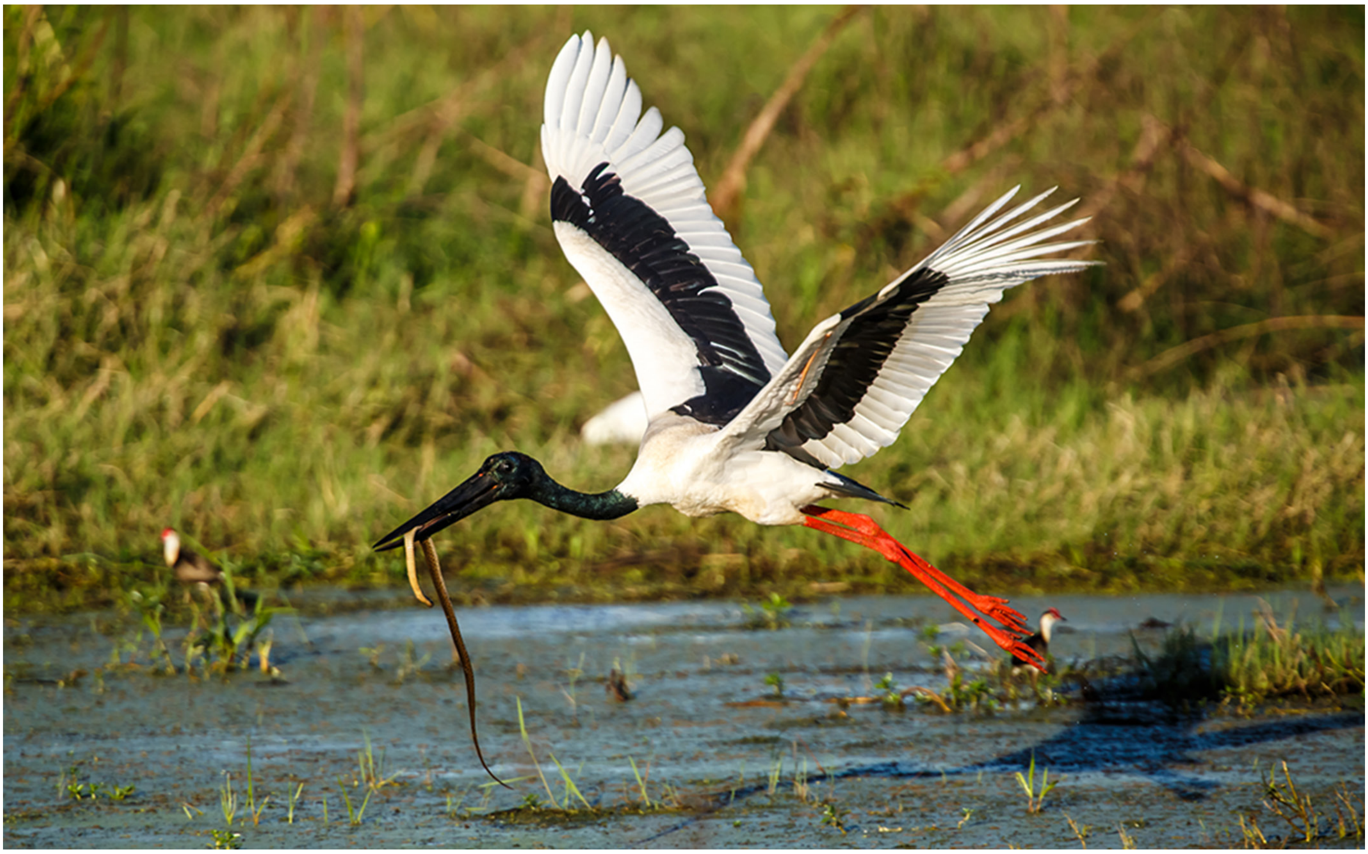

**Figure 2.** Black-necked Stork with Keelback Snake *Tropidonophis mairii.* Taken 24 May 2014.

are far more active on the dam wall at night than by day (reflecting dangerously high diurnal temperatures: Shine and Madsen 1996). Thus, most snakes are taken while inactive in their diurnal retreats. In contrast, turtles are attacked by day, while they are actively moving across open ground. The raptors locate their prey from a considerable distance, and swoop in to seize the slow-moving turtles before they can reach the safety of water on the other side of the road. Turtles also cross the dam wall in large numbers at night, when raptors are inactive.

2. *Prey species involved.* – Fogg Dam houses a diverse array of snake species, and at least two taxa of turtles. However, our documented cases of predation involve a limited set of species. Of the snakes, nocturnal surveys along the dam wall show that Water Pythons (*Liasis fuscus*) are the most abundant local species, but these powerful snakes shelter in deep soil cracks by day where they are inaccessible to avian predators (Shine and Madsen 1996). Four colubrid species are abundant also, but we recorded only two of these species being eaten. Golden Tree Snakes (*Dendrelaphis punctulatus*) are safe from storks because these agile, fast-moving snakes are primarily arboreal (Shine 1991). Slatey-Grey Snakes (*Stegonotus cucullatus*) are large, muscular and formidable, and are not as closely associated with water as either of the other two species (Brown *et al.* 2005). Keelback Snakes (*Tropidonophis mairii*) and Macleay's Water Snakes (*Enhydris polylepis*) are smaller and often found in shallow water at the margins of swamps – exactly the places in which Black-necked Storks forage. Fully aquatic Arafura filesnakes (*Acrochordus arafurae*) are found in the dam, but less often than the above species. Studies at two nearby sites recorded major variation in the snake species consumed by White-bellied Sea-Eagles: a single *Enhydris polylepis* and a single *Acrochordus arafurae* were recorded under eagle nests at Kapalga, whereas 47 *A. arafurae* (but no *Enhydris*) were recorded at a site on the Mary River (Corbett and Hertog 2011). Local variation in habitat types and snake abundances, and perhaps raptor behaviour, may explain such variation.

Fogg Dam contains Short-necked Turtles (*Emydura tanybaraga*) as well as Long-necked Turtles (*Chelodina oblonga*), but the former species is relatively rare (<1% of records of turtles crossing the dam wall: R. Shine, pers. obs., 2003) and thus, rarely taken by raptors. The same pattern was recorded in Corbett and Hertog's (2011) study of eagle predation at nearby floodplain sites. Long-necked Turtles are especially vulnerable because they move from permanently-inundated areas into highly-productive ephemeral wetlands following flooding (Kennett 1996). That migration requires risky terrestrial travel between the dam and the floodplain below, rendering the turtles easy targets for any predator large enough to attack them. In New South Wales, in contrast, the White-bellied Sea-Eagle preys upon the Clarence River Short-necked Turtle (*Emydura macquarii*) more often than the Eastern Long-necked Turtle, possibly reflecting the former species' greater abundance and its habit of sunning in groups on exposed logs and fence posts in wetlands

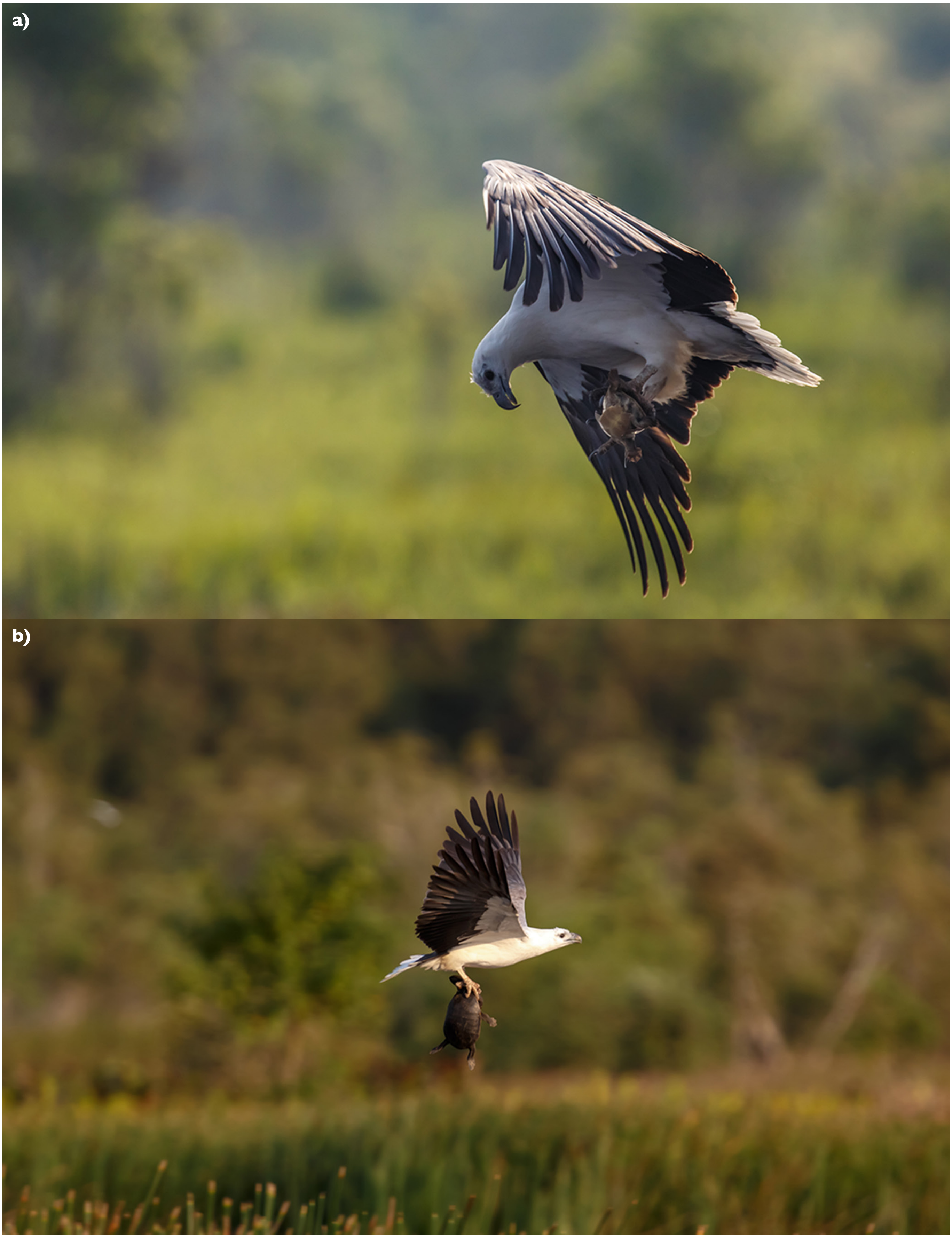

**Figure 3.** (a) Male White-bellied Sea-Eagle with Long-necked Turtle (taken 29 June 2014), and (b) female White-bellied Sea-Eagle with Long-necked Turtle (taken 13 July 2014).

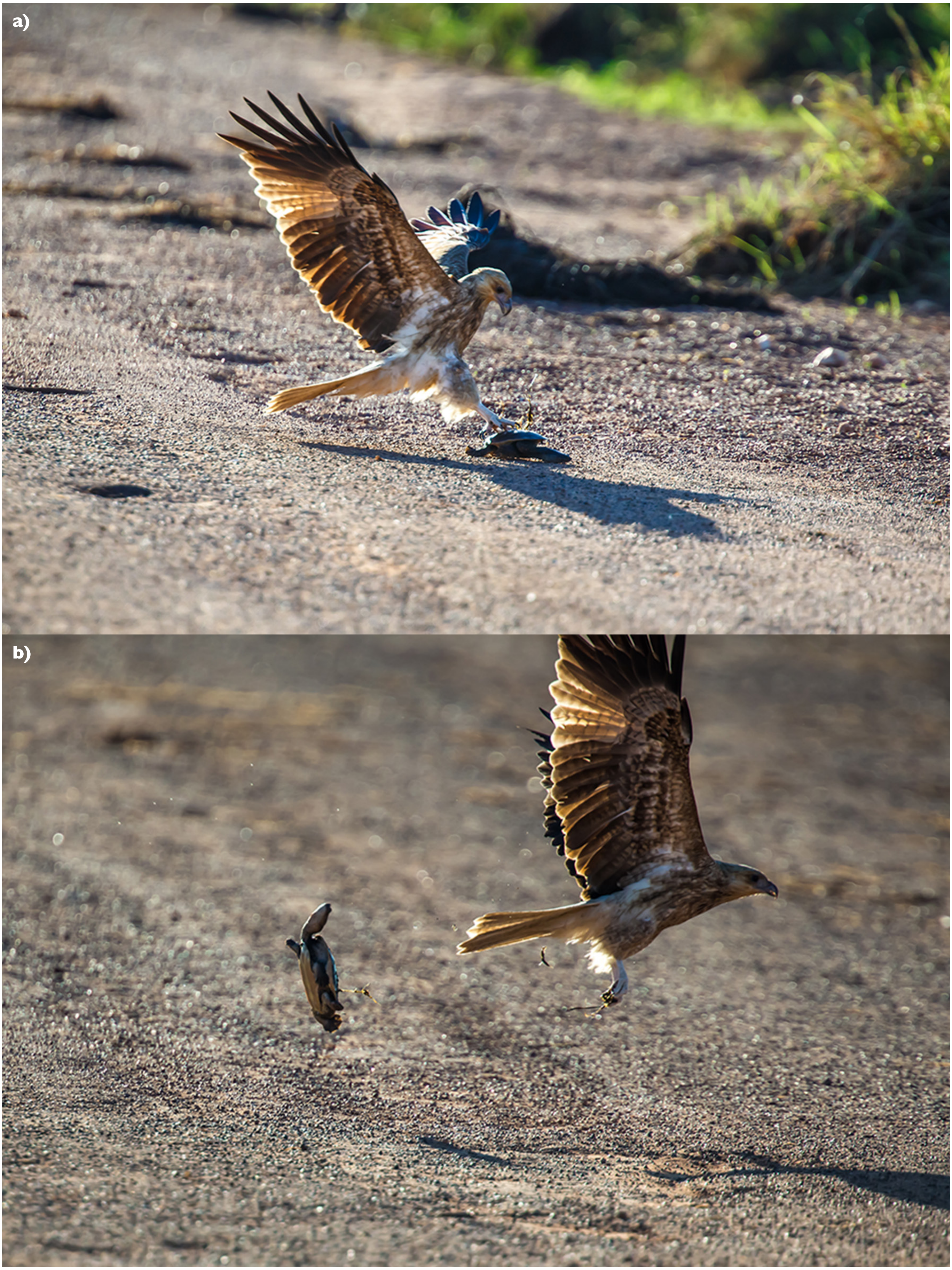

**Figure 4.** Whistling Kites attempting (and failing) to seize a Long-necked Turtle while the bird is in flight (a) and (b), taken 26 May 2014.

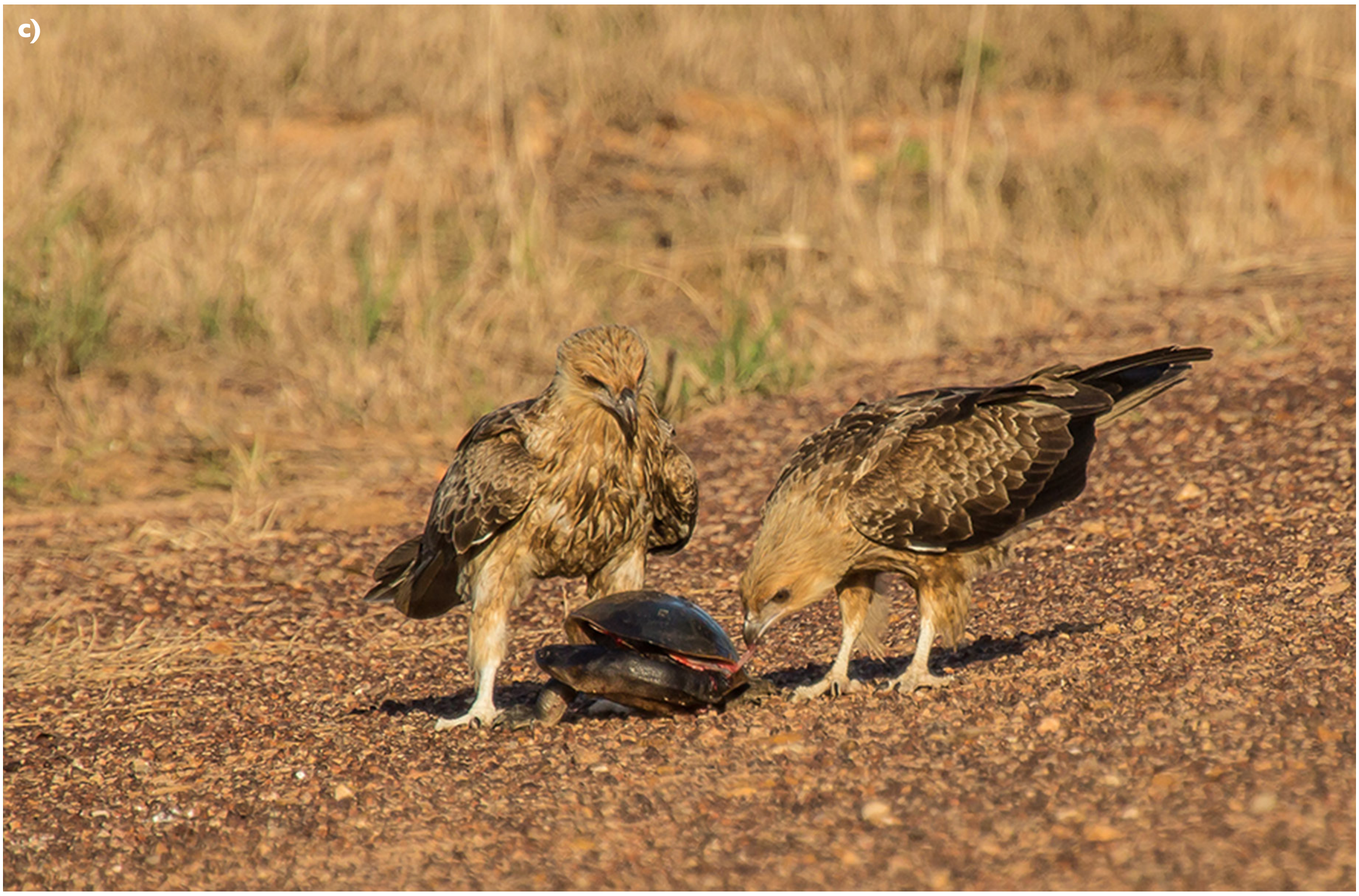

**Figure 4.** (c) A pair of Whistling Kites consuming Long-Necked Turtle (taken 2 May 2014).

(Greg Clancy, pers. comm.).

3. *Sizes of prey items.* – Our photographs show predation on relatively large (adult) snakes, and on medium to large turtles. This pattern may be an artefact: smaller prey items are less visible to a photographer, biasing our observations towards instances of the consumption of relatively large prey. This is especially true for snakes. Even a small turtle is easily visible on the open wall of the dam, but in practice most of the turtles we see crossing the wall are relatively large. Presumably, juvenile snakes (and turtles) are also taken by the abundant herons and egrets that gather to feed on small fishes on the dam wall. Experimental studies have shown high consumption rates of tadpoles and fishes placed out in trays on the dam wall (Beckmann *et al.* 2011), and we suspect that juvenile snakes would meet a similar fate.
4. *Location on dam wall.* – Because the predation events we observed were due to a small number of individual birds, those events inevitably were restricted to areas where those birds foraged. The Black-necked Storks we watched often roamed slowly over an area along the margins of the swamp <100 m long, over a period of several hours. Thus, snakes using shelter-sites within the storks' foraging range were at a disproportionately high risk. Another pair of Black-necked Storks foraged in an area west of our own focal pair, but some parts of the swamp margins undoubtedly were far riskier for snakes than others.

   Spatial heterogeneity in risk also applies to turtles crossing the dam wall. Raptors can see turtles from a considerable distance, so that the zone of danger from a specific predator is larger than is the case with the storks. This factor reduces spatial heterogeneity of risk. However, the width of the dam wall (and thus, the amount of time for which a crossing turtle is vulnerable) varies about fourfold along the length of the dam. A turtle choosing to cross at the widest point may have far less chance of reaching the other side before being intercepted.
5. *Season.* – Predation on reptiles was observed primarily as the landscape began to dry out, after the end of the monsoonal rains. At this time of year, extensive shallowly-inundated grassy edges attract thousands of small fishes, providing ideal foraging sites for Macleay's Water Snakes (Shine *et al.* 2004). Likewise, Keelback Snakes can find small (recently-metamorphosed) frogs and fishes along these pond margins (Brown and Shine 2006).

In summary, this paper illustrates how non-professionals can add substantially to our knowledge of wildlife biology, even with respect to an area and a set of study species that have been the focus of detailed and prolonged research. Scientists and naturalists can learn a great deal from each other (Tewksbury *et al.* 2014).

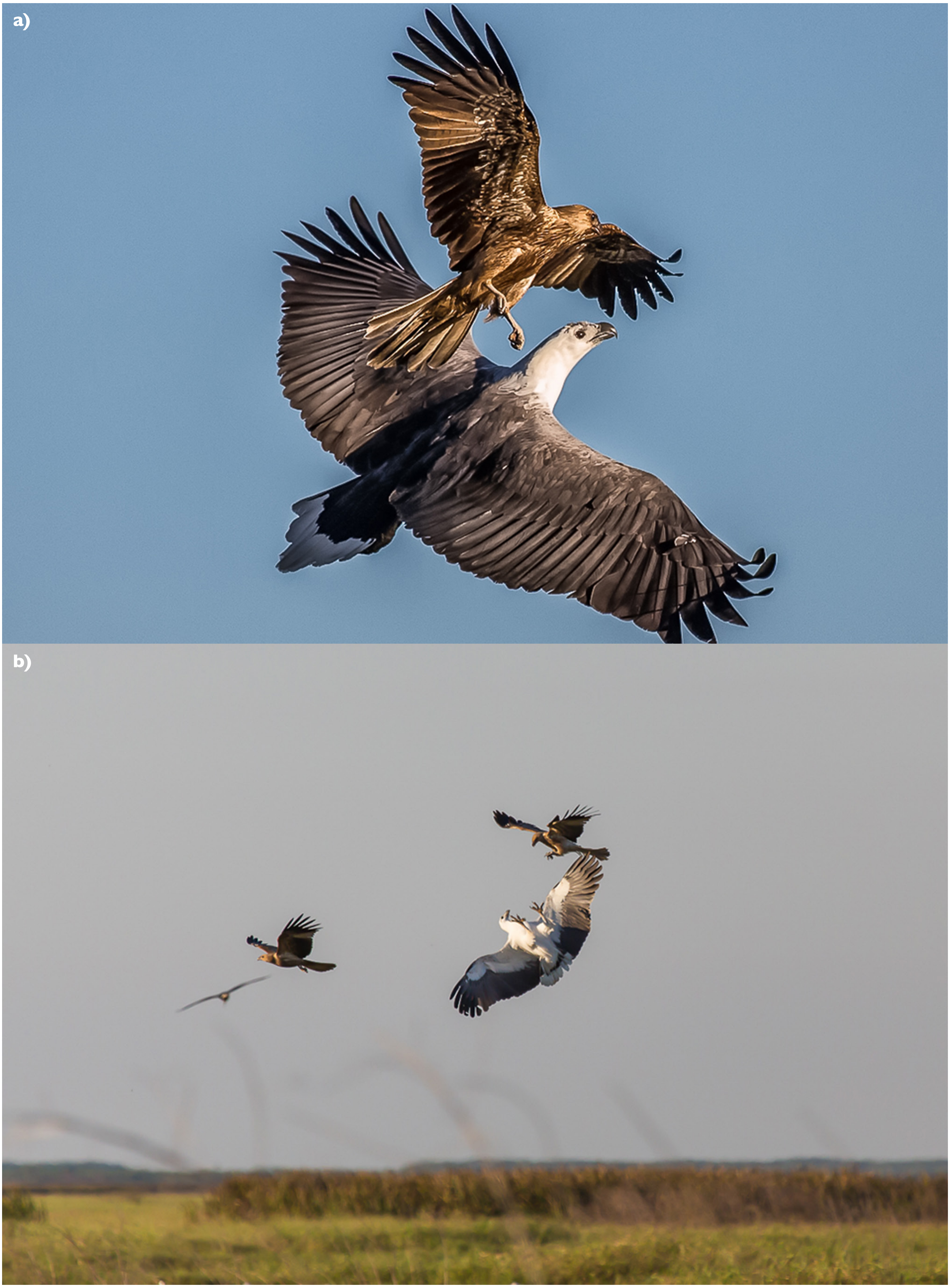

**Figure 5.** Aerial combat between White-bellied Sea-Eagle and Whistling Kite (a) taken 29 April 2014, (b) taken 9 August 2014.

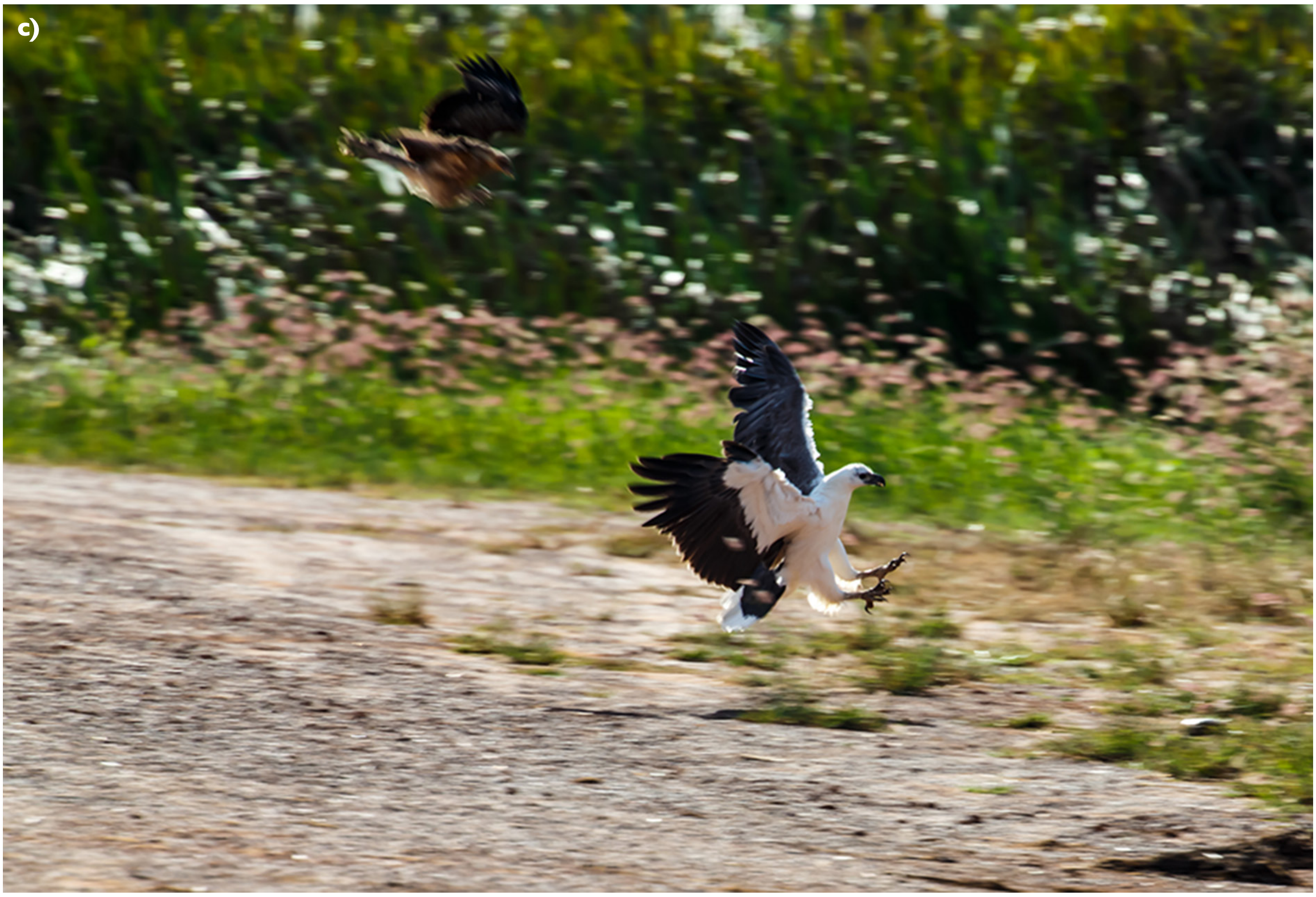

**Figure 5.** (c) Whistling Kite following closely behind White-bellied Sea-Eagle as it attacks turtle (taken 2 June 2014).

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